

Department
Biogeochemical Processes

The Department Biogeochemical Processes explores key processes and organisms that regulate exchanges of energy, water and elements between ecosystems and their surroundings. We use observations, experiments and models to improve understanding of how human activities are altering ecosystem function, and the consequences for sustainability and regional and global climate.

Climate change affects ecosystems

Terrestrial ecosystems are undergoing rapid and unprecedented change. Humans have transformed more than half of the global land surface by direct activities such as deforestation and management of land for agriculture or pasture. All land areas experience effects of climate change, elevated carbon dioxide levels and air pollution. At the same time, the land surface is a key component of the global climate system and an important regulator of atmospheric composition.

Our department seeks basic understanding of the biogeochemical functioning of ecosystems, and the consequences of current changes for climate and the sustainability of ecosystem services supplied by vegetation and soils.

Quantifying responses and feedbacks in complex, coupled systems requires a range of tools and approaches.

- **Field studies** determine fluxes of energy, water and gases between land and atmosphere in ecosystems ranging from tropical forests and savannahs to managed forests and grasslands in Germany.
- **Laboratory and field experiments** manipulate individual factors such as temperature, biodiversity or nutrient availability to document how different components of the ecosystem respond to changing environmental conditions.
- We develop **new analytical tools** that allow us to evaluate the importance of processes across a range of spatial and temporal scales.

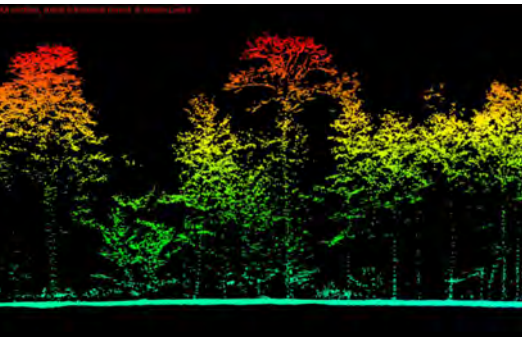
Our research is targeted on particular processes and ecosystems where significant uncertainties exist and where large responses to climate change or direct human management are expected.

Because we work at a variety of spatial scales, from organism to ecosystem to region to globe, we collaborate actively with the other departments of the Institute to integrate across these scales using isotopic tracers, models, and spatial analysis tools.

Regions of special emphasis include
- investigation of local land management in Germany and the arc of deforestation in Brazil;
- documenting disturbance and carbon allocation in tropical forests of the Amazon Basin;
- determining the transit time and age of carbon in a range of global ecosystems

The origin, fate and vulnerability of organic matter stored in soils

Although soil organic matter is fundamental to human well-being and to a number of global biogeochemical cycles, we lack basic understanding of processes that store carbon in soils, and how factors such as climate, organisms, and mineral composition combine to determine how long it remains stabilized.



Several groups of our department work on this topic, with goal of synthesizing information on soil carbon stocks, the chemistry and age of the organic matter, and how those are affected by changing vegetation, temperature, moisture, and land management. Our special contribution is the use of radiocarbon to determine the age of carbon in soils and to measure how fast carbon moves through soils back to the atmosphere.

Understanding plant allocation, respiration, defense and mortality

Plants use the products of photosynthesis for respiration, growth, defense, storage, and transfer to roots and soil. However, we do not have good theories to predict how allocation strategies among those pathways are determined, or how those allocation patterns will respond to changes in environmental-conditions or the community composition. We have developed methods to use carbon isotopes to track allocation pathways and the residence time of carbon in plants. Experiments using drought to manipulate the supply and allocation of carbon in trees provide information on the links between carbon and water cycles and the causes of tree mortality and respiration allow improved understanding of how plants respond to stress.

The role of functional traits and biodiversity in biogeochemical cycles

The biota that inhabit ecosystems determine the role of biological systems in global element cycles. A major challenge lies in determining what aspects of the organisms present are required to adequately describe the response of ecosystems to change. Research ranges from experiments that manipulate biodiversity, to investigation of the long-term effects of land management. A new aspect of this is to understand the controls on the functional traits of microbial communities and how these are reflected in the diversity of gases emitted from soils.

Reconstruction of Past Vegetation and Climate

Plants make compounds that, through their isotopic composition, record environmental variables. These relationships are defined using our ongoing studies and experiments, and can then be applied to reconstruct past variations recorded in tree rings, paleosols, or lake sediments. Ongoing research looks at the effects of past drought in German forests, and changes in monsoons on the Tibetan plateau.

Portrait of the Director

Susan E. Trumbore has been the Director of the Department Biogeochemical Processes since 2009. She is also Professor of Earth System Science at the University of California Irvine and Honorary Professor in the faculty of Chemistry and Geology at the Friedrich Schiller University of Jena. Trumbore's main research contribution is the application of radiocarbon to study the dynamics of carbon cycling in plants and soils. Starting in 2014, she is the Editor-in-Chief of‚Global Biogeochemical Cycles.' She is a member of the speaker team for the Collaborative Research Center AquaDiva and a member of the German Center for Integrative Biodiversity Research iDiv.

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